New Principle Schemes of Freight Cars Bogies

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In the article the issue of perspective running parts for freight cars of new generation is considered and additions to the outdated existing classification of bogie are developed, namely introduction of such types of suspension is suggested.The results of theoretical studies are presented by means of modeling the movement of the car in the software "Universal Mechanism" to determine the influence of the first stage of spring suspension in Barber type bogie (type 18-100 and analogues) on energy efficiency (resistance to movement) and the estimated value of the decrease in resistance to movement.A concept for a fundamentally new design of a freight car bogie for high-speed traffic has been prepared, based on fundamentally new technical solutions with elastic-dissipative bearing elements, as well as a concept for the modernization of the Barber-type bogie (type 18-100 and analogues) by introducing axle suspension on the 1520 mm gauge.

Key words: Bogie, springsuspension, axle suspention, resistance to movement, elastic-dessipative bearing

1 Introduction

The problem of imperfection of the running gear of cars, especially in cargo traffic on the world's railways, is widely described by scientists of various countries, including the authors of the article in previous publications [1 – 3, 12, 16, 17]. The most acute problem is for freight wagons with a gauge of 1520 mm, where the most common undercarriage is a moribund Barber type bogie (family of 18-100 bogies), whose service life reaches 40 ... 42 years (in Ukraine, the lifetime of bogies of the type 18-100 for railroad cars, issued since 1975 to 01.02.1984, is 42 years).

The current two-pronged task for today is the development of new breakthrough technologies in car building, namely the creation of original structures and the use of new materials in the running part of freight cars in order to increase the speed of traffic, reduce unsprung masses, reduce the impact on the way, increase the energy efficiency of rolling stock, also the creation of ways to modernize existing bogies to improve their technical and economic characteristics.

2 A new approach to the classification of bogies

Generally accepted classification of bogies of the freight cars suggest four basic types of organization of spring suspension, as shown in Fig. 1: axle-box suspension, central, axle-box and central cradle suspension; boxed and central non- cradlesuspension [4].

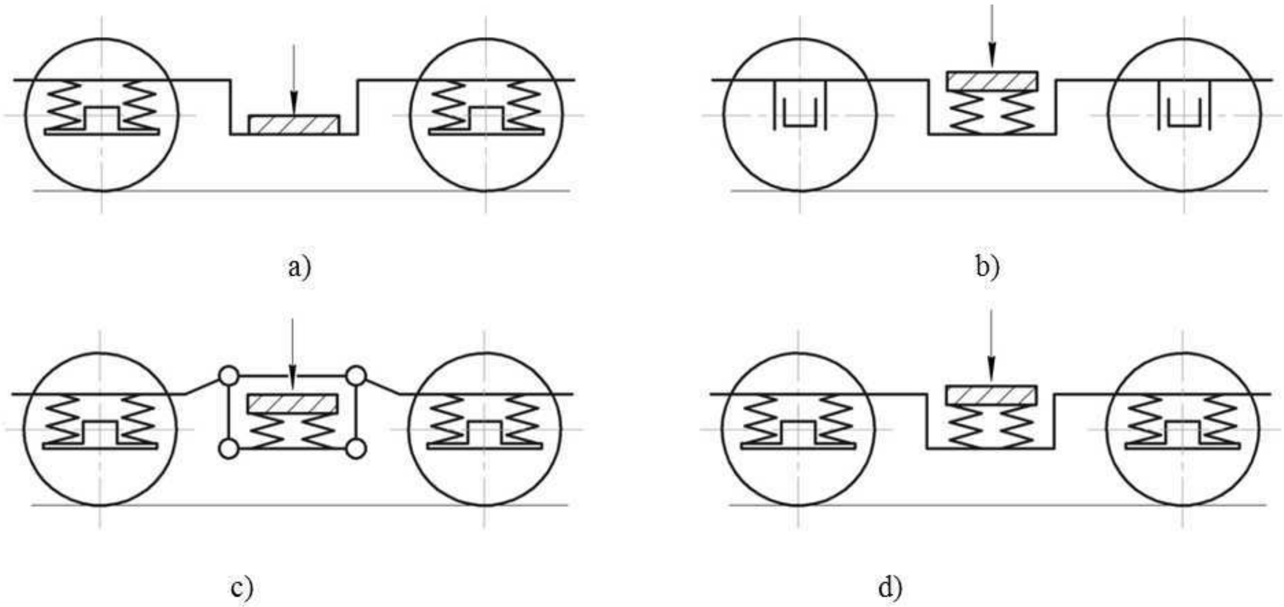

Fig. 1 *Types of spring suspension of carriages: axle-box suspension (a); central suspension (b); axle-box and central cradle suspension (c); boxed and central non- cradlesuspension (d)*

Innovative technologies for designing modules of load-bearing and elastic elements are based on original design solutions and new materials. For example, the technical solutions created by the authors, the new bogie of the passenger car "efWING" (Fig. 2) using CFRP (Carbon Fiber Reinforced Plastic) [6] have in their design an elastically dissipative carrier element - an analog of the side frame. Such a constructive approach is not included in the framework of the existing classification, therefore we have expanded the classification of bogies by types of spring suspension by more flexible typical schemes. The authors of [5-8] carry out theoretical and experimental studies of a number of new principle circuits using elastic (elastically dissipative) load-bearing elements presented in Fig. 3: combined axle-box suspension with elastic frame (a), combined central suspension with elastic frame (b), elastic frame (c), multi-stage combined: bow and central suspension with elastic frame (d), multi-stage combined: axle and central cradle suspension With an elastic frame (f), an elastic bolster (g). The bogie "efWING" with this classification refers to a multistage combined: axle-box and central suspension with an elastic frame.

Fig. 2 *The bogie of the passenger wagon "efWING" with the use of an elastically dissipative carrier element*

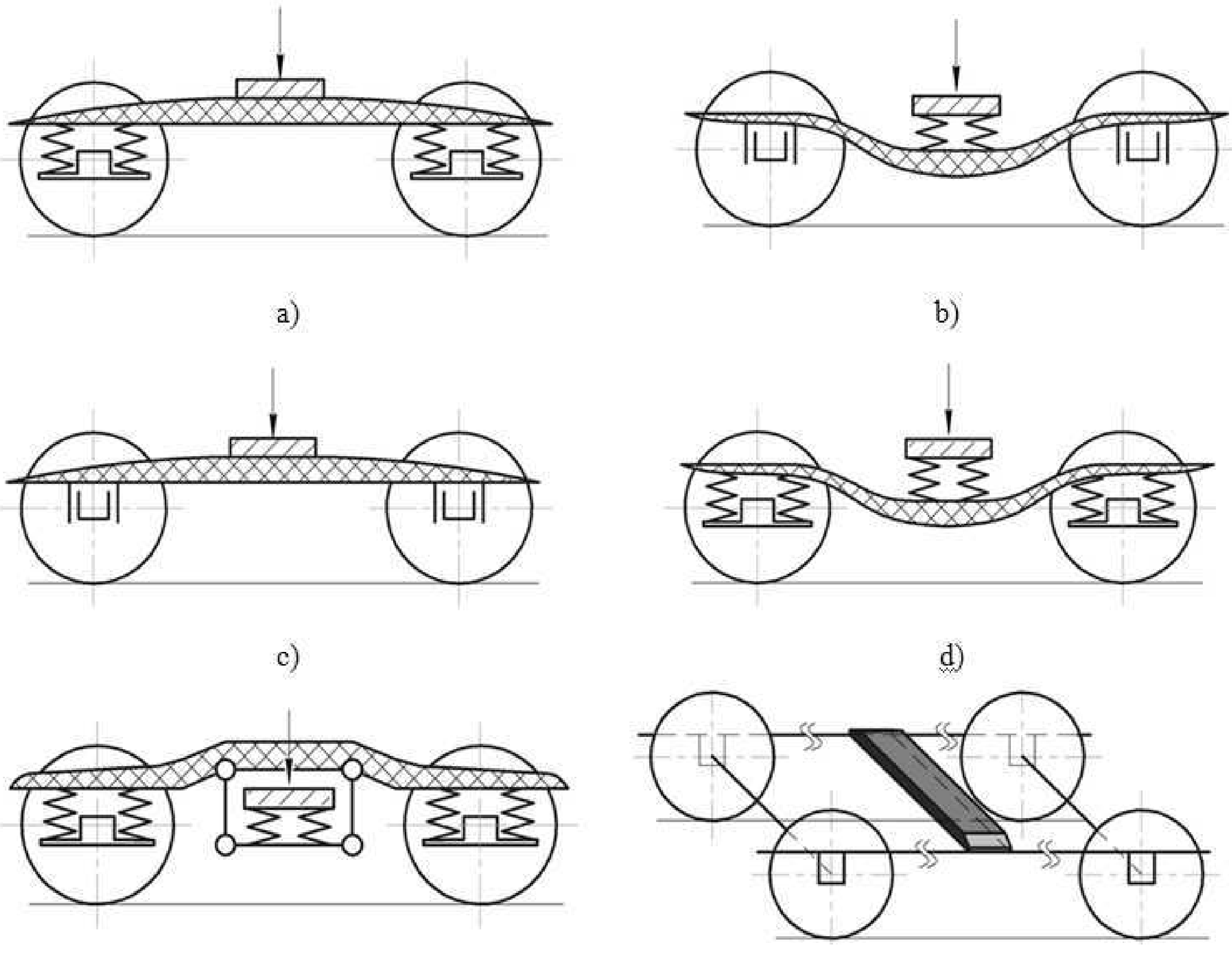

Fig. 3 *Perspective types of spring suspension of wagons: combined axle-box suspension with elastic frame (a), combined center suspension with elastic frame (b), elastic frame (c), multi-stage combined: axle-box and central suspension with elastic frame (d), multi-stage combined: axle and central cradle suspension with elastic frame (f), an elastic bolster (g)*

One example of the author's design of a bogie with multifunctional load-bearing elastic-dissipative elements, in which leaf springs that provide a multi-stage combined suspension (axle-box and central cradle suspensions with an elastic frame) are used, is shown in Fig. 4. Authors collect theoretical and experimental researches of constructive variants of bogies and their modules for development of the project of high-speed bogie of the carriage.

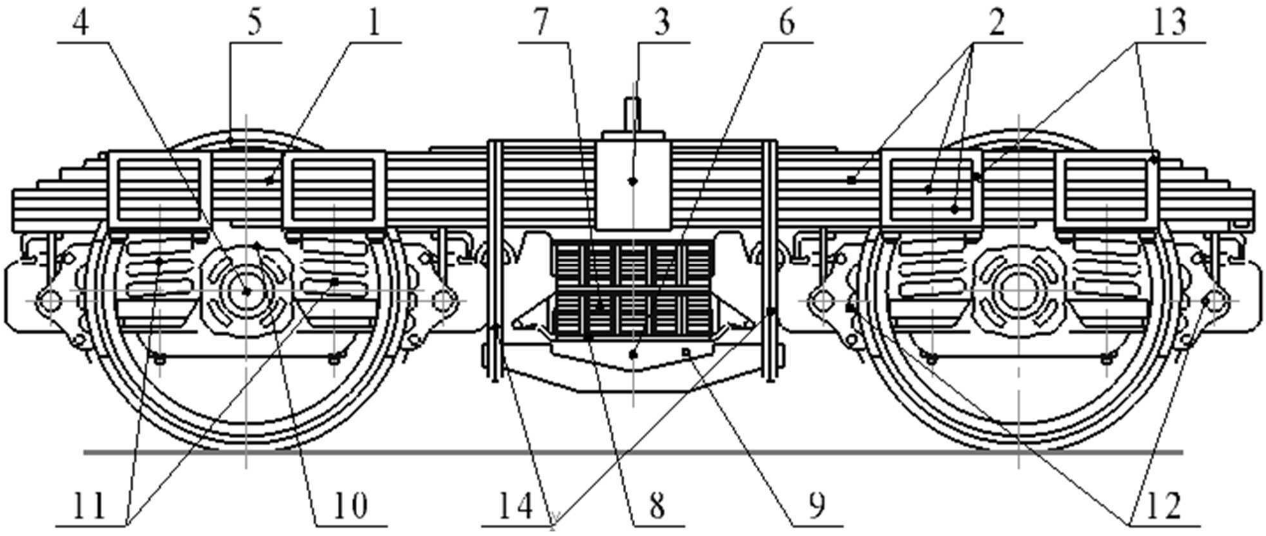

Fig. 4 Scheme of the invention on the method for creating a bogie with multifunctional bearing elements providing multi-stage combined spring suspension (axle-box and central cradle suspension with an elastic frame): side frame 1, leaf springs 2, yoke 3, the axles ofwheel pairs 4, wheel pairs 5, central spring suspension 6, elliptical springs of Galakhov 7, subsurface connection8, under-beam beams 9, axle-box suspension 10,springs 11, braking equipment 12, springs of axle-box suspension 13, hanging clamps 14

3 Investigation of the dynamic properties of Barber type bogies (type 18-100 and analogues) with an axle-box stage of suspension

The authors of the articles in previous publications [2 - 9] present original technical solutions for the improvement of Barber type bogies(type 18-100 and analogues) by creating an axle-box stage of suspension, using the "axle box pedestal brace". The scheme of such a technical solution is shown in Fig. 5 (a and b). According to the preliminary strength calculations by the finite element method, it was found that equipping the axle box with an axle string allows to reduce the level of maximum equivalent stresses in the most stressed areas of the side frames (zone of radius transition R55) by 30-50%, and also to increase the operating speed up to 120 km/h on an equal basis with similar designs of bogies (bogie of type 18-9750, China acid-base tank wagon CGS74). It should be noted that the issue of energy efficiency (resistance to movement) of such a design is not sufficiently studied by modern scientists (one of the fundamental works of this kind can be attributed [10, 13 - 15]).

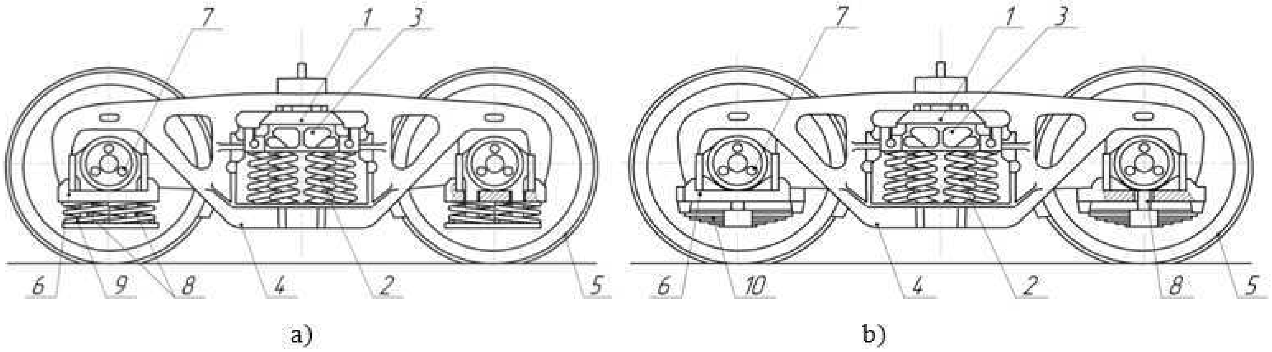

Fig. 5 Three-piece bogie with the pedestal brace and primary bogie suspension: 1 – bolster, 2 – bolster suspension, 3 – friction shock absorbers, 4 – side frame, 5 –wheelsets, 6 – pedestal brace, 7 – axle-box, 8 – rods connecting the bearing with a stiffener, 9 – primary spring suspension, 10 – leaf springs

In this part of the article, the results of modeling the movement of a freight car are considered, namely the calculation of the resistance to movement for each of the eight wheels in conventional units. The simulation was carried out in the "Universal Mechanism 6.0.0" software package on the straight track without curves and inclinations, the unevenness of the track was formed on the basis of the data of the railroad car-trackers of Ukrainian railways [11], the speed of movement was 30, 60 and 90 km/h. Modeling was carried out for a single car equipped with bogies of type 18-100 (without an axle suspension) in a normal technical condition (hereinafter referred to as an existing car) and for a wagon equipped with bogies of type 18-100 with a deflection of the pedestrian suspension stage - 40 mm (hereinafter wagon with two stages of suspension). The simulation time is 23 s. For the values of the resistance of movement the following designations are accepted: 1L - wheel of the first wheelset, left wheel, 2L - wheel of the second wheelset, left wheel, etc. 1R - wheel of the first wheelset, the right wheel, etc.

In Fig. 6 – 8 show the results of simulating the resistance to movement of each wheel of an existing car at speeds of 30, 60 and 90 km/h. Table 1 summarizes the average resistance values for the movement of an existing car.

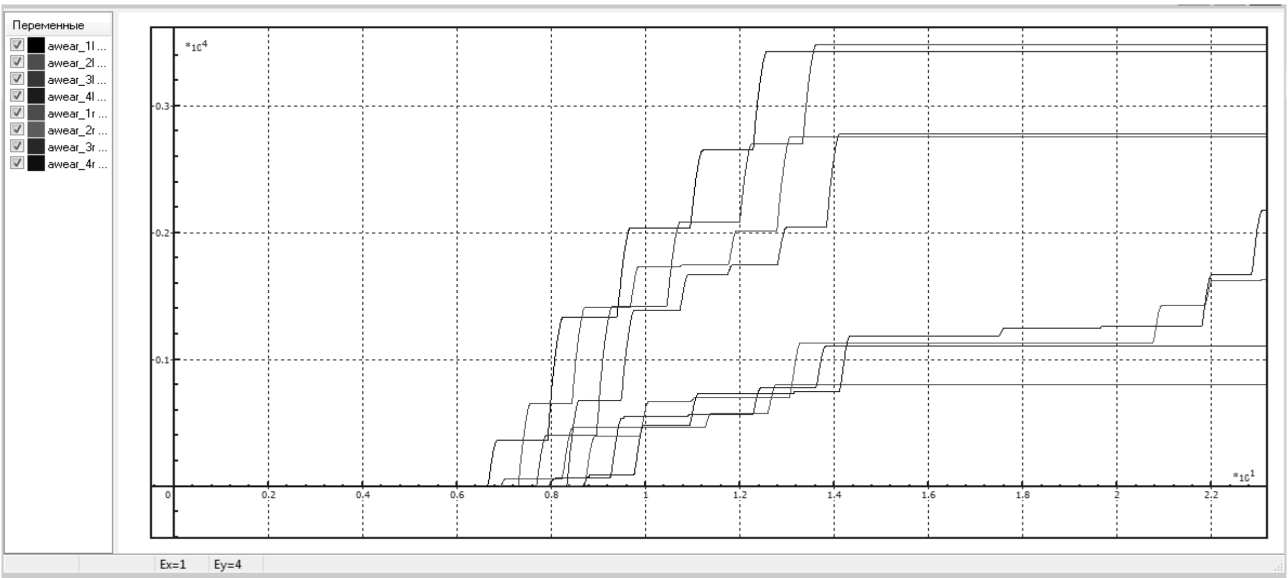

Fig. 6 *Resistance to the movement of each wheel of an existing wagonat a speed of V = 30 km/h*

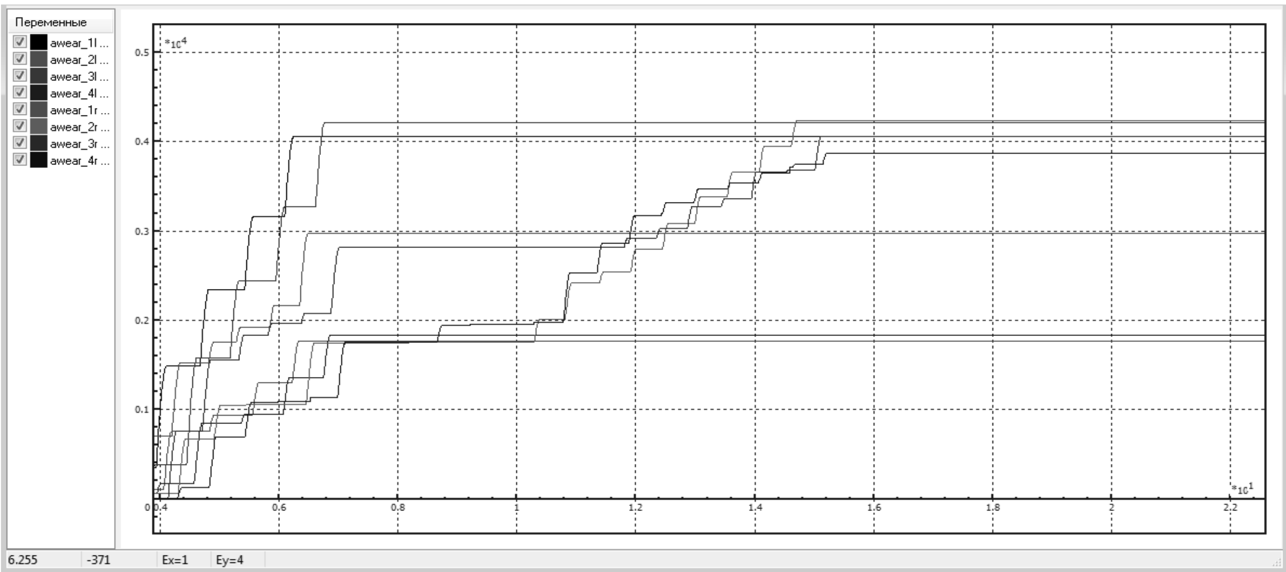

Fig. 7 *Resistance to the movement of each wheel of an existing wagonat a speed of V = 60 km/h*

Tab. 1 *Average values of resistance to movement of the existing wagon at speeds of 30...90 km/h*

V/Wheel	1 L	2 L	3 L	4 L	1 R	2 R	3 R	4R
30 km/h	2095	353	1990	620	1664	717	1557	755
60 km/h	3266	1408	3310	1430	3285	2618	2772	2462
90 km/h	4153	2342	4404	2877	8282	2813	7653	3879

Similarly, a simulation was carried out for a wagon with two suspension stages.

Table 2 summarizes the average values of resistance to movement of the wagon with two stages of suspension.

In Fig. 9 graphically shows the results of modeling the resistance to movement of each wheel of an existing wagon and a wagon with two stages of suspension.

Tab. 2 *Average values of resistance to movement of the wagon with two stages of suspension at speeds of 30, 60 and 90 km/h*

V/Wheel	1 L	2 L	3 L	4 L	1 R	2 R	3 R	4R
30 km/h	1864	300	1751	552	1481	616	1370	661
60 km/h	2907	1253	2846	1269	2917	2296	2384	2092
90 km/h	3571	2061	3919	2474	7122	2503	6742	3394

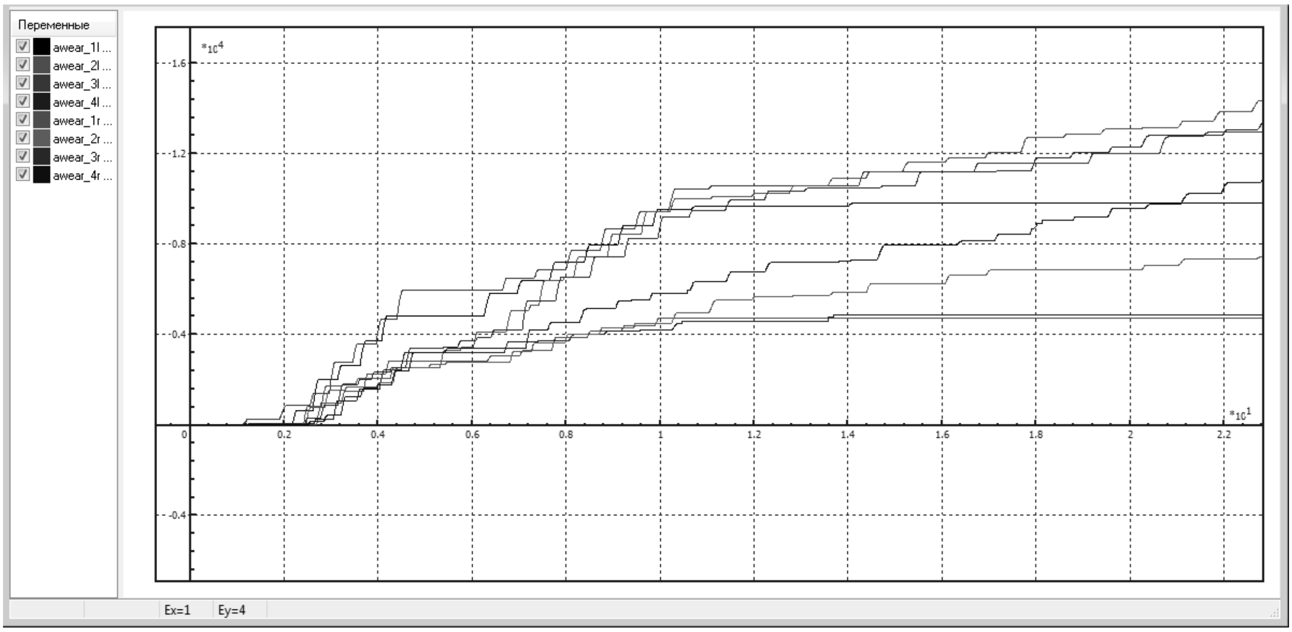

Fig. 8 *Resistance to the movement of each wheel of an existing wagon at a speed of V = 90 km/h*

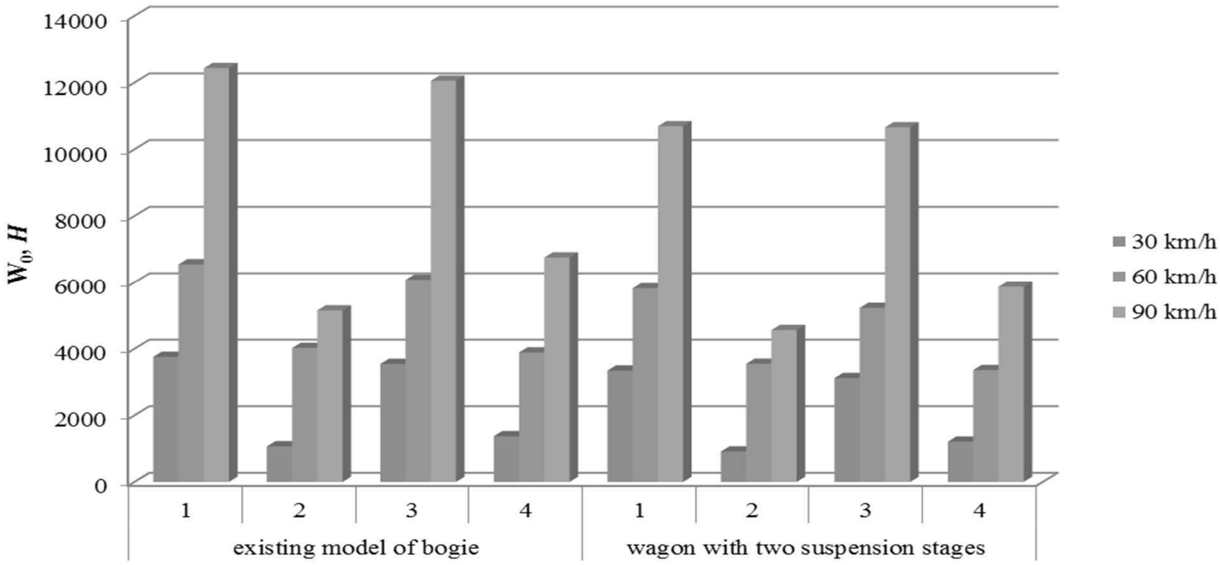

Fig. 9 *Histogram of the mean value of the resistance to the movement wheels of an existing wagon and a wagon with two suspension stages at speeds of 30, 60, 90 km/h*

As can be seen from Tables 1, 2 and Fig. 9, the decrease in the resistance of the movement of a laden wagon with the introduction of a pedestrian suspension stage with a static deflection of 40 mm averages 11-15% (13 ± 2%).

4 Conclusions

1. A promising way to create running gear for freight cars of the new generation is to create multifunctional load-bearing elastic-dissipative modules providing improved technical and economic indicators.

2. The existing classification of types of spring suspension of wagons is obsolete and existing technical solutions go beyond it. The authors proposed to supplement the classification of perspective species of spring suspension.

3. The proposed technical solution for the modernization the bogie of the freight car wagon 18-100 type, in addition to solving the problem of increasing the strength and reliability of operation, provides a reduction in the resistance to movement by an average of 13% (according to calculated data).

4. The paper proposes a two-pronged solution: the concept of a fundamentally new design of a freight car wagon for high-speed traffic is presented, based on fundamentally new technical solutions, and a concept for the modernization of the most common model of a bogie on a 1520 mm gauge is developed.

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